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Safety and Ergonomics Risk Assessment (SERA): A Customized Ergonomics Assessment Tool for Automobile Manufacturing

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Abstract: Musculoskeletal disorders continue to be a leading source of lost workdays across all industries. Common ergonomics assessment tools may include criteria extraneous to the stresses at specific companies or industries. Therefore, the creation of assessment tools, based on scientifically validated methods, with industry- or company-specific stresses may be of benefit.

The BMW Group has developed the Safety and Ergonomics Risk Assessment (SERA) tool. This ergonomics assessment method incorporates the most up-to-date scientific methods and international standards, and is used worldwide in all production facilities of the BMW Group. As noted above, a major advantage of SERA over conventional ergonomics tools is the focus on ergonomics stresses common to automobile manufacturing and the consequent exclusion of irrelevant parameters, thereby reducing the time, effort, and training required for workplace assessments. Other advantages include the international uniformity of assessments and a web- and database-implementation allowing for easily comparable international reporting. The implementation of this method at the BMW Group has enabled a greater transparency for ergonomics across all international plants, and more effective and targeted ergonomics interventions.

This publication will outline the basic motivation for SERA, highlight the relevant scientific sources and international standards, and general steps of an evaluation.

Keywords: ergonomics assessment tool, automobile manufacturing, international standards

1. Introduction

1.1 Literature Review

Work-related MSDs continue to be a leading source of lost workdays and associated costs, across all industries. In 2019 the costs of overexertion, exertion, and repetitive motion in the United States were estimated to exceed 18 billion dollars and comprise 33% of total workplace injury costs (*Liberty Mutual Workplace Safety Index*, 2019). For countries with a high socio-demographic index, the incidence rate of specific work-related MSDs (low back and neck pain) has even shown a slightly increasing trend between the years of 1990 and 2019 and are both within the top 25 causes for disability-adjusted life years in 2019 (Vos et al., 2020). Specifically, within automobile manufacturing, rates of work-related MSD symptoms reportedly range from 79% (both genders) to 98% (for women) performing physical manufacturing tasks (Arghami, Kalantari, Ahmadi Kionani, Zanjirani Farahani, & Kamrani, 2016; Ghasemkhani, Aten, & Azam, 2006; Hussain, 2004). Therefore, the assessment of workplaces, identification of high-risk tasks, and implementation of countermeasures to reduce work-related MSDs and their associated risk factors is a high priority in the automobile and other similar manufacturing industries.

1.2 Background

The most common risk factors leading to work-related MSDs have been well established and tools have been developed to enable workplace assessments based on those risk factors. This means that practitioners have a plethora of ergonomics assessment tools available to them for assessing workplaces. Since none of the conventional assessment methods met the desired criteria by the BMW Group, the SERA (Safety and Ergonomics Risk Assessment) project was launched with

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the goal of becoming first IT solution for a comprehensive ergonomics and safety assessment tool in the automotive industry and fulfilling a wide range of goals:

- More accurate stress and risk assessment based on the latest scientific findings,
- Phase-adequate assessment processes for vehicle projects,
- User-friendly interface design,
- Implementation of an improved reporting and steering system,
- Extensive administration options,
- Intelligent access rights.

The screening tool SERA was designed based on scientifically validated methods with the aim of providing a whole-body ergonomics screening. Additionally, the tool allows for the assessment of the workplace surroundings, mental stresses, and a hazard and risk assessment, although those will not be considered further in this paper. A major advantage of SERA over conventional, widespread, screening methods, e.g. EAWS, KIM, REBA, etc. is the customization to specific stresses, allowing all stresses of modern automobile manufacturing to be covered while disregarding unnecessary stresses. Further, using a web-based application approach enables SERA to have an intuitive user interface and maintain a database of stresses for all manufacturing workplaces, thus making comparisons and reports at any level of organization entity feasible and simple.

2. Methods & Discussion

2.1 Ergonomics Criteria

A workplace assessment in SERA is comprised of 13 criteria, 7 of which focus on various dimensions of physical ergonomics, e.g. postures, forces, and loads. Each of these 7 ergonomics criteria focuses on a specific body area or type of force/load (see Table 1). All criteria assessments are multidimensional, including at least repetition/frequency and intensity of a given stress. The result of each criterion is both a quantitative risk score and a traffic light color (red, yellow, and green, to represent low-, medium-, and high-risk workstations respectively). Notably, the quantitative score represents a sum of the individual stresses, whereas the traffic light color represents the worst-case for the individual stresses (see Figure 1). This enables a two-fold consideration by the practitioner; highlighting the worst-case stresses (via the traffic light color) and prioritization between workplaces with the same traffic light color (via the risk score). The overall ergonomics for a workstation is further summarized using the sum of risk scores for the ergonomics criteria and a further worst-case traffic light for the seven ergonomics criteria.

Table 1. SERA Criteria mapping to body parts and respective scientific sources and/or standards used to define the criteria.

Criterion	Body part/ Stress focus	Source(s)
1	Neck	DIN EN 1005-4: Safety of machinery - Human physical performance (DIN, 2009)
2	Shoulders	DIN EN 1005-4: Safety of machinery - Human physical performance (DIN, 2009)
3	Torso/ Back	DIN EN 1005-4: Safety of machinery - Human physical performance (DIN, 2009) EAWS: European Assembly Worksheet (Schaub, Caragnano, Britzke, & Bruder, 2013)
4	Whole body forces	DIN EN 1005-3: Safety of machinery - Human physical Performance (DIN, 2002) Der montagespezifische Kraftatlas (BGIA-Report, 3/2009) (Wakula et al., 2009)
5	Hand & finger forces	DIN EN 1005-3: Safety of machinery - Human physical Performance (2002) Der montagespezifische Kraftatlas (BGIA-Report, 3/2009) (Wakula et al., 2009)
6	Lower limbs (Sitting, standing, and walking)	LV 50: Bewegungsergonomische Gestaltung von andauernder Steharbeit (Berger, Caffier, Schultz, & Tripple, 2009)
7	Load handling	Leitmerkmalmethode Manuelle Arbeitsprozesse (Steinberg & Arbeitsmedizin, 2007) NIOSH Lifting Equation (NIOSH, 1994)

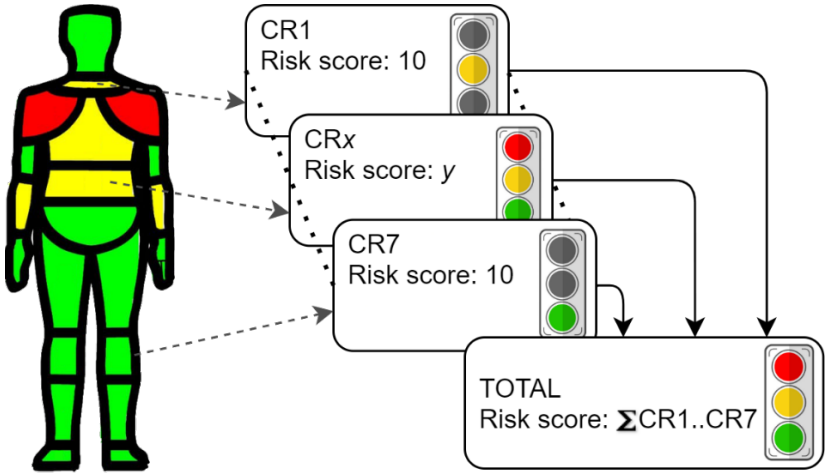

Figure 1. Visual representation of the ergonomics criteria in SERA. Each criterion assesses stresses on specific body parts and/or types of forces and loads.

Each criterion has various levels of detail, dependent on the types of stresses typically found in automobile manufacturing. Unfortunately, the exact details of SERA are confidential, but in summary, criteria measure the following stresses:

- Postural criteria (Criteria 1, 2, 3, and 6):
  - Intensity of stress, e.g. flexion angle
  - Duration of stress, e.g. time
  - Dynamic or static nature of the stress
- Force and load criteria (Criteria 4, 5, and 7):
  - Posture during force exertion, e.g. body or hand/fingers
  - Intensity of the force, e.g. measured force, weight, etc.
  - Frequency of the force, e.g. number per minute, distance carried, etc.

2.2 Advantages of SERA

As discussed earlier, the customization of SERA to fit the specific needs of automobile manufacturing is one of the primary advantages of the system. In comparison, other methods, e.g. REBA (Hignett & McAtamney, 2000) or EAWS (Schaub et al., 2013), necessarily incorporate a wide range of stresses which are irrelevant to automobile manufacturing. Examples of stresses commonly considered in conventional methods (for the purposes of broad applicability) include manual handling of loads >25lbs, wheel and/or floor conditions for carts, extreme temperatures, etc. While this is advantageous for the method itself, making it applicable to a wide range of industries and stresses, necessitates additional (wasted) time and training of users. Should a more detailed analysis be required due to an unusual or specific task, the users may supplement the SERA analysis with another method. This truly makes SERA a screening tool, which can be performed relatively quickly, but simultaneously provide sufficient details.

Another advantage of SERA is its web-based implementation and worldwide use. Since the stresses in SERA were defined based on internationally recognized science and standards, the SERA system can be used in all worldwide production facilities of the BMW Group. This means that all analyses in SERA are comparable, and one can use the information from another facility or production line to glean best practices and when planning new production lines. Additionally, the added reporting functionalities in SERA enable direct comparisons, targeted interventions, and easy monitoring across all facilities.

2.3 Process for a SERA Analysis

Training is a prerequisite to gaining SERA system access. Each department designates persons with the responsibility for performing and maintaining the SERA analyses for all workplaces in a given area. The training is roughly comprised of ergonomics fundamentals, system use training, and practice evaluations. Refresher trainings are required at regular intervals.

Workplace assessments with SERA are straightforward. Each workplace is coded with a department, location, and task description. This makes the workplaces easy to find, update, and report on. The ergonomics assessment itself can occur directly in the system, or using a paper record sheet which is transferred to the system afterward. In observing ergonomics stresses the assessor can observe the short cyclical activities (typically about 1 minute) performed at each workstation. Thanks to the repetitive nature of automobile manufacturing, these tasks can be observed repeatedly until all the relevant stresses have been captured. Depending on the need, force, weight, and distance can be measured on the spot. The duration of an assessment is heavily dependent on the complexity of the task being observed, but most assessments can be completed within 30 minutes.

Assessments must be updated whenever changes occur to the workstation or task being performed. Such changes are automatically detected due to interfaces to the production planning systems, which report task/workplace changes to the SERA system. Once specified thresholds are exceeded (e.g. time, MTM codes, etc.) for workplace changes, the persons responsible for the SERA analyses are notified that an analyses requires updating. Thanks to automated versioning, the same SERA analysis can be loaded and updated. This allows for a detailed tracking of historical changes over time.

3. Conclusion

The BMW Group has developed SERA, an internal ergonomics assessment and screening tool which is customized to the needs of automobile manufacturing. A relatively small number of criteria were developed based on a mix of scientific investigations and international standards, which cover the most relevant ergonomics stresses. SERA is used across all international manufacturing facilities at the BMW Group and therefore enables comparability, uniformity, and easy reporting.

SERA assessments themselves use a combination of risk indices and traffic light colors to indicate ergonomics stresses, enabling a two-fold prioritization of ergonomics interventions. Each of the ergonomics criteria includes at minimum a multidimensional assessment of stresses; intensity and repetition. All assessors at the BMW Group must undergo a standardized training prior to system access. Assessments can be performed relatively quickly, thanks to the repetitive nature of an automobile manufacturing line and the reduced complexity of the automobile-manufacturing-specific stresses which are considered in SERA.

The implementation of SERA at the BMW Group has enabled a greater transparency for ergonomics across all international plants, and more effective and targeted ergonomics interventions.

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